Progress in CERES Clear-sky Aerosol Optical Thickness Dependent Shortwave ADM over Ocean

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radiance to flux: clear-sky SW ADM over ocean

1. Sort measured radiances into angular and wind speed bins $(w;\theta_0,\theta,\phi)$ and calculate mean radiances;
2. Calculate mean flux by integrating the mean radiances over all θ and ϕ;
3. Define anisotropic factor;
4. Convert measured radiances to fluxes;

$$\hat{I}(w;\theta_0,\theta,\varphi)$$

$$\hat{F}(w;\theta_0)$$

$$R(w;\theta_0,\theta,\varphi) = \frac{\pi\hat{I}(w;\theta_0,\theta,\varphi)}{\hat{F}(w;\theta_0)}$$

$$F = \frac{\pi I_o(w;\theta_0,\theta,\varphi)}{R(w;\theta_0,\theta,\varphi)}$$

Aerosol in Ed.2 Clear-sky ADM over Ocean

- AOD is not directly accounted for in Ed.2 ADM;
- It is implicitly accounted for by a theoretical scale factor when radiances are converted to fluxes (*Loeb et al., 2005*).

$$F = \frac{\pi I_O}{R\left(\frac{R^{th}_{I_O}}{R^{th}_{\hat{I}}}\right)}$$

- R is the anisotropic factor for converting $\hat{I}$ at (w, θ_0, θ and ϕ) to F;
- $R^{th}_{\hat{I}}$ is the theoretical anisotropic factor for $\hat{I}$;
- $R^{th}_{I_0}$ is the theoretical anisotropic factor for I_0 .

How to quantify the performance of an ADM?

RMS of normalized radiance differences between ADM-prediction and observation

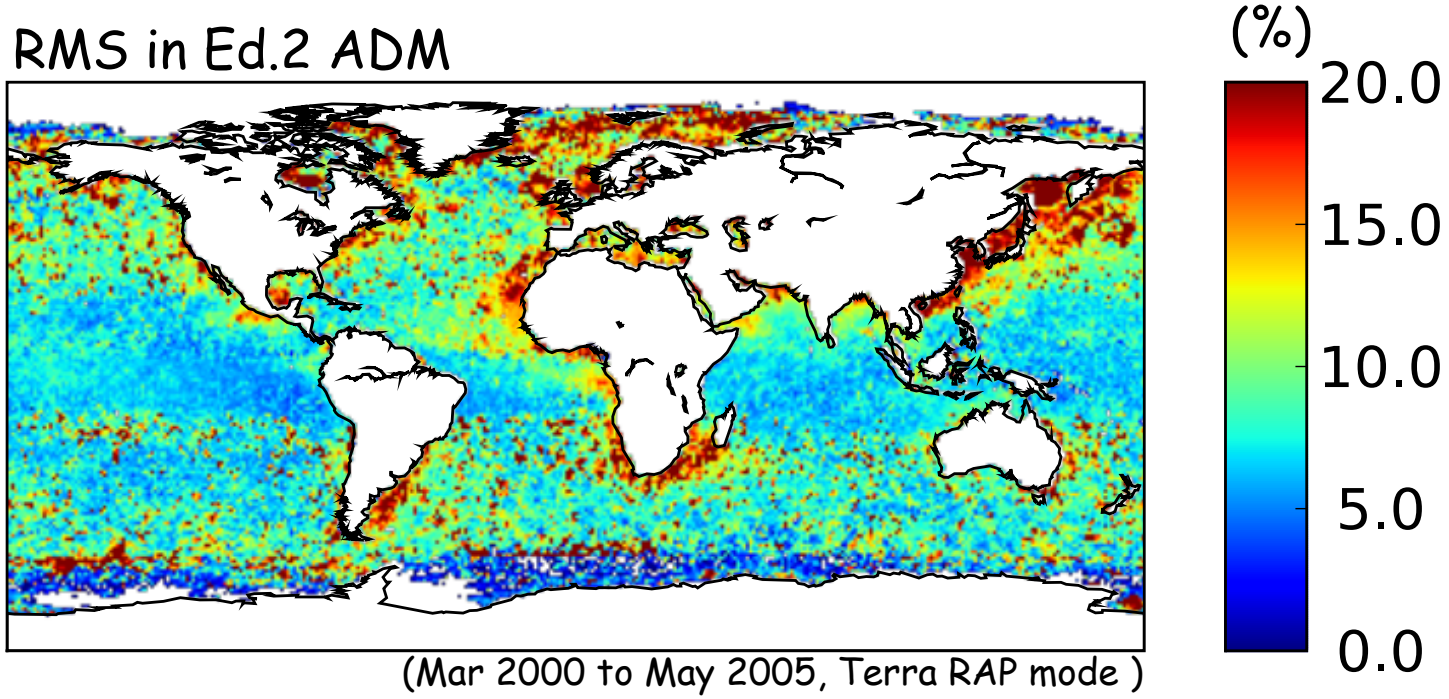
$$RMS = \sqrt{\frac{1}{n}\sum\left(\frac{\hat{I}^i}{\langle \hat{I} \rangle} - \frac{I_O^i}{\langle I_O \rangle}\right)^2}$$

$\hat{I}^i$ is the radiance value of ADM at (w, θ_0, θ and ϕ),

I_o^i is the radiance value of the theoretical model at (w, θ_0, θ and ϕ),

$\langle\ \rangle$ is the grid mean.

Where to improve?



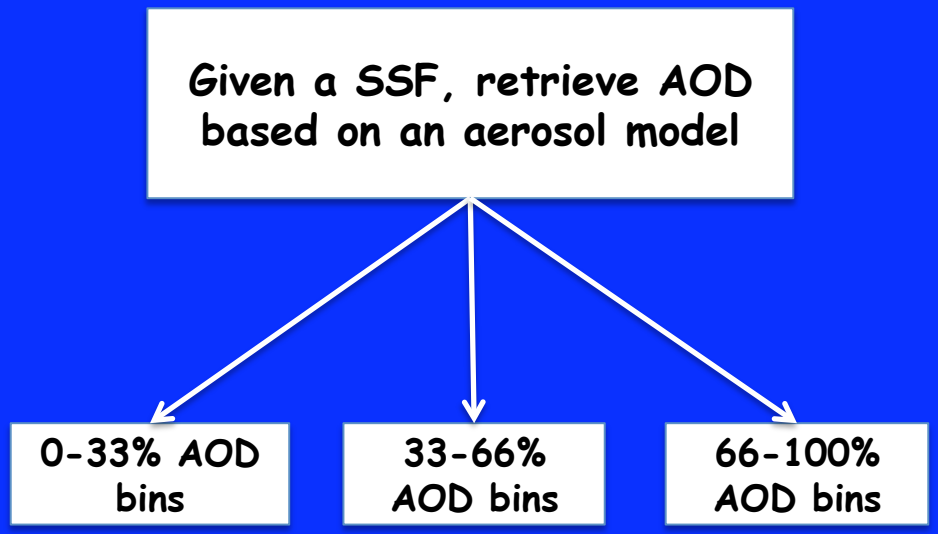
RMS is a function of AOD and aerosol type

1: AOD-classified ADM

2: AOD-and-type classified ADM
(two-model-minimal approach with MODIS bands 1 and 2)

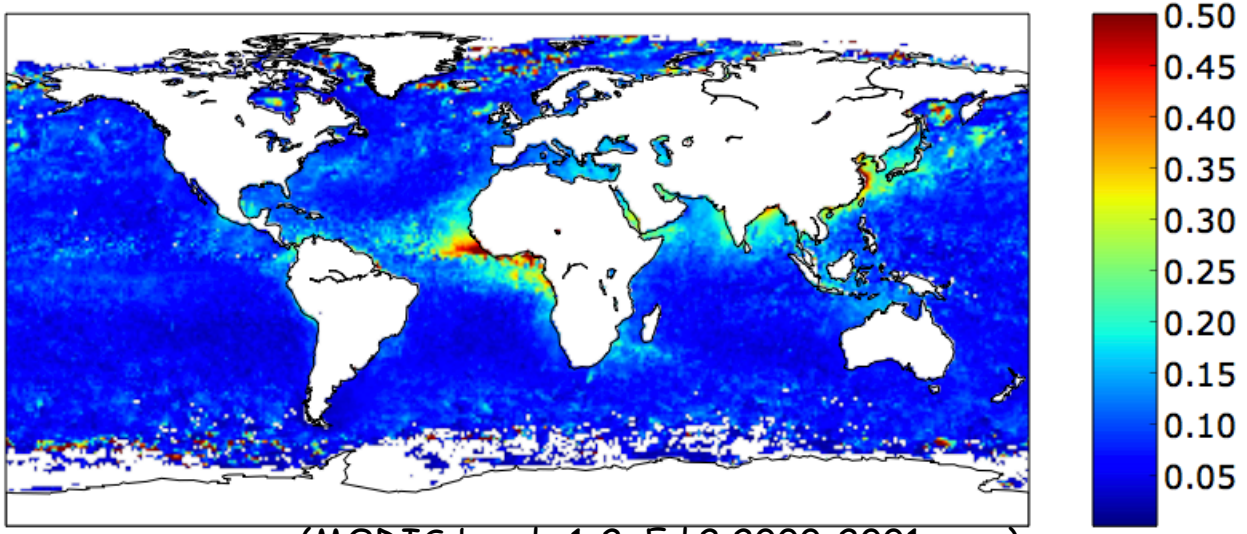
3: AOD-and-type classified ADM
(AOD-fine-mode-fraction approach with MODIS bands 1 and 2)

1: AOD-classified ADM



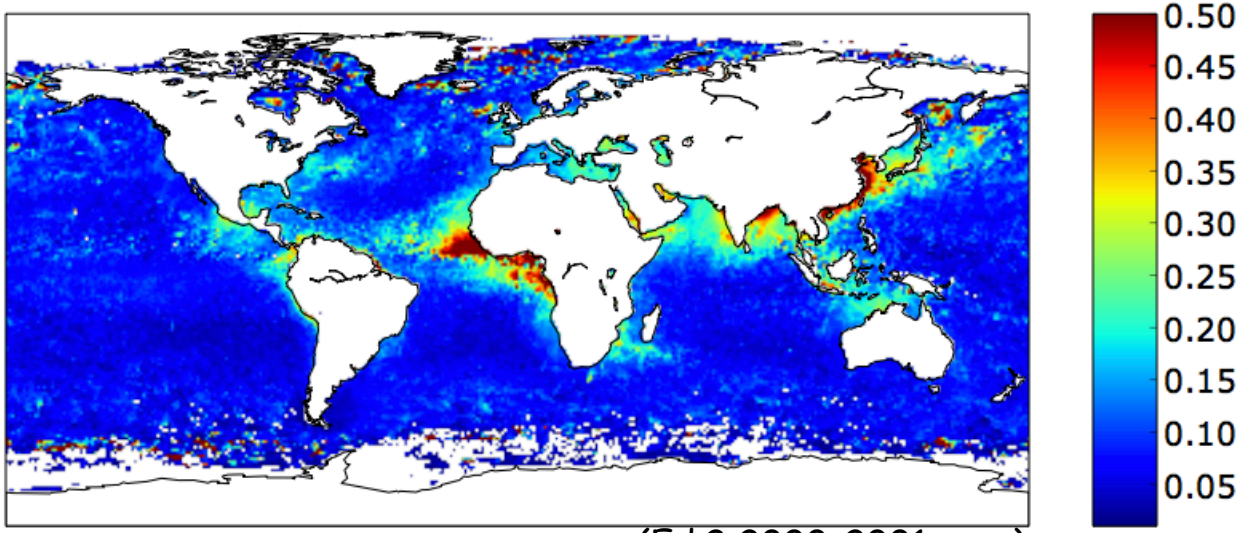
AOD retrieval – comparison with MODIS

CERES



(MODIS bands 1-2, Ed.2 2000-2001 raps)

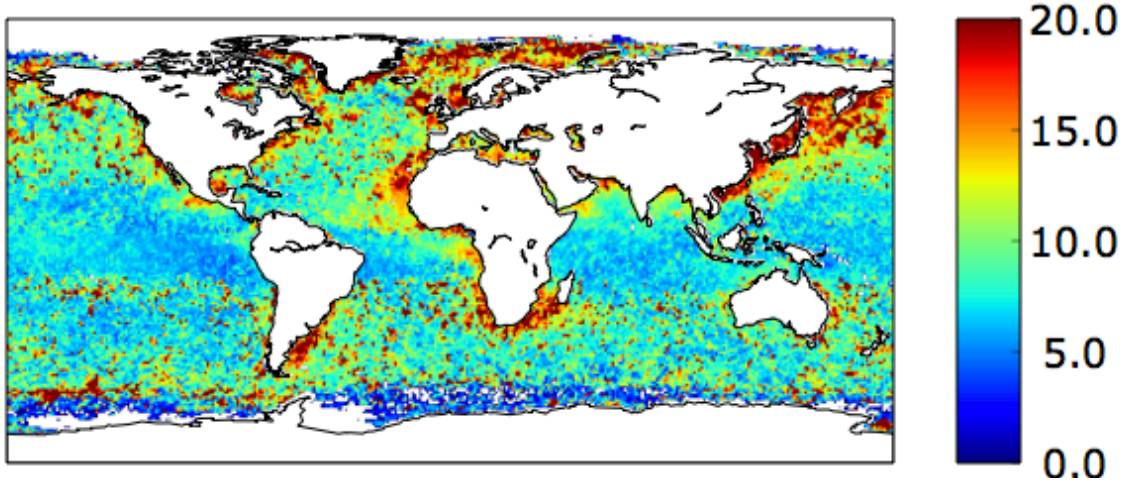
MODIS



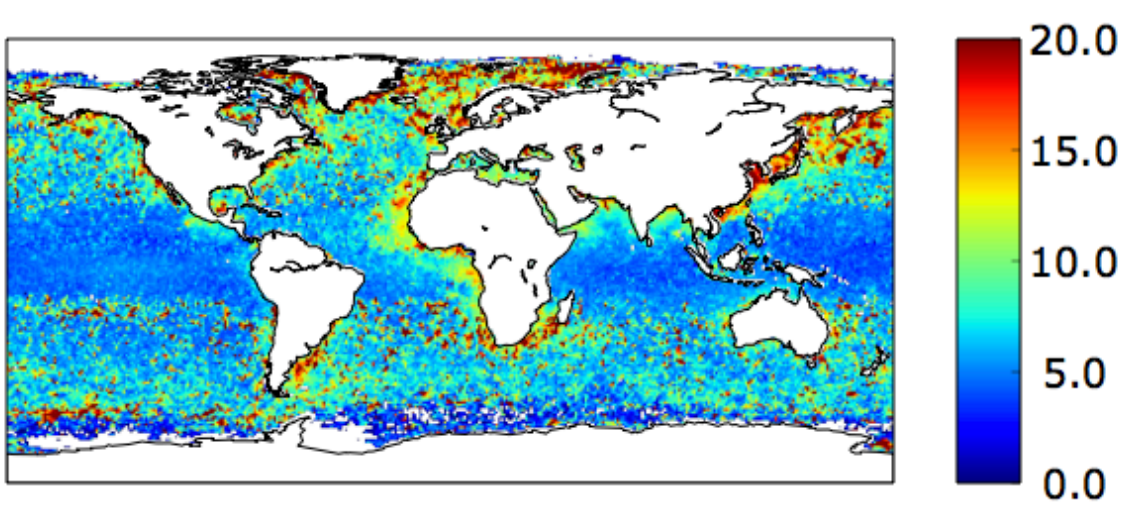
(Ed.2 2000-2001 raps)

AOD-classified ADM -- OPAC maritime-tropic model

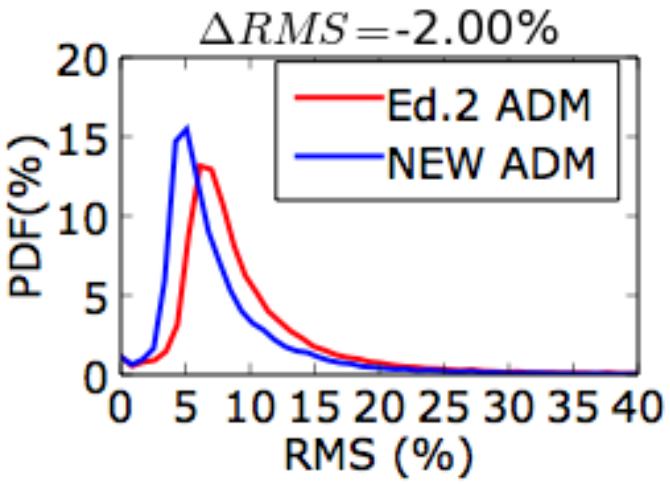
Ed.2 ADM RMS



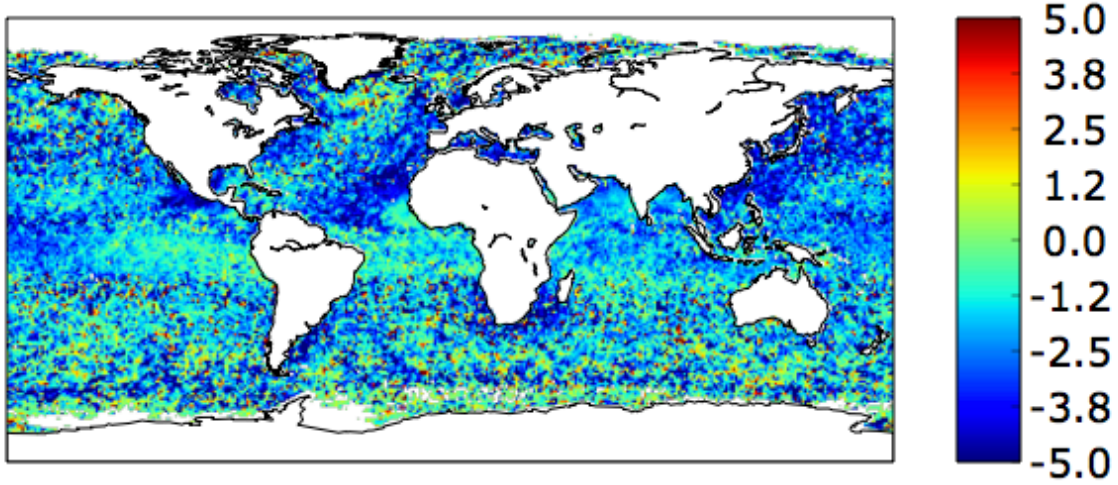
New ADM RMS

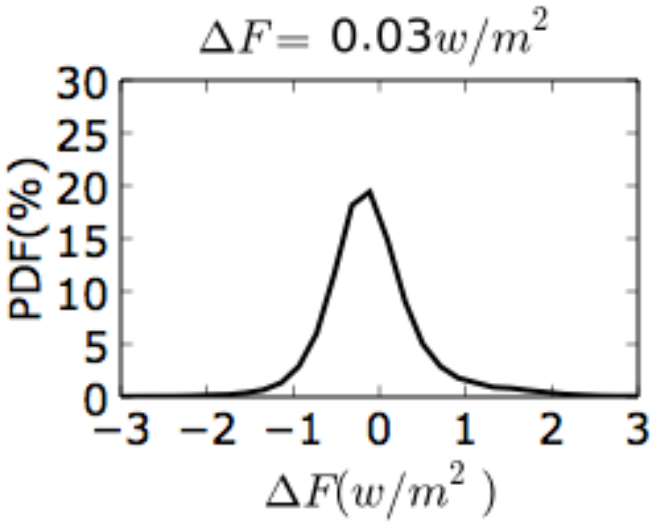


AOD-classified ADM -- OPAC maritime-tropic model

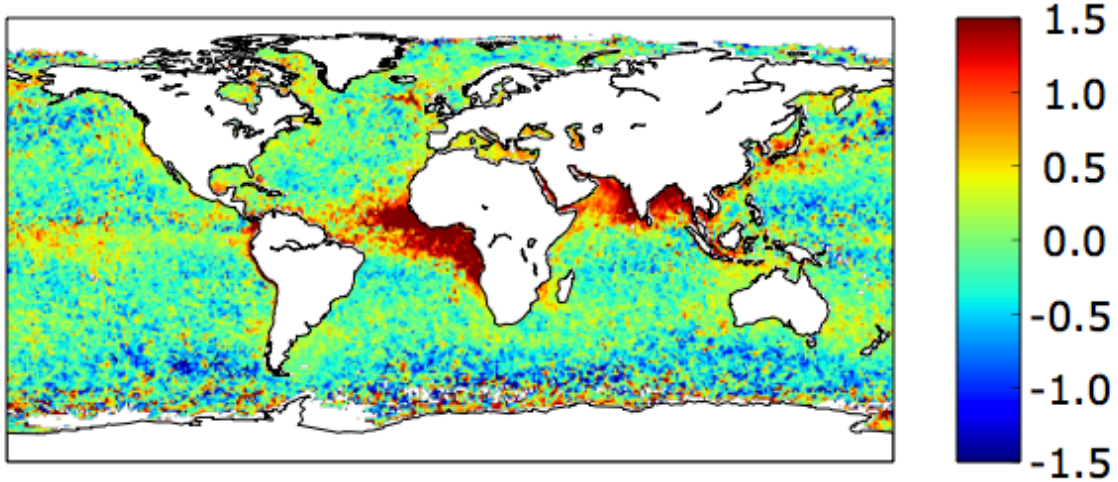


New – Ed. 2 ΔRMS (%)





ΔF (w/m²)



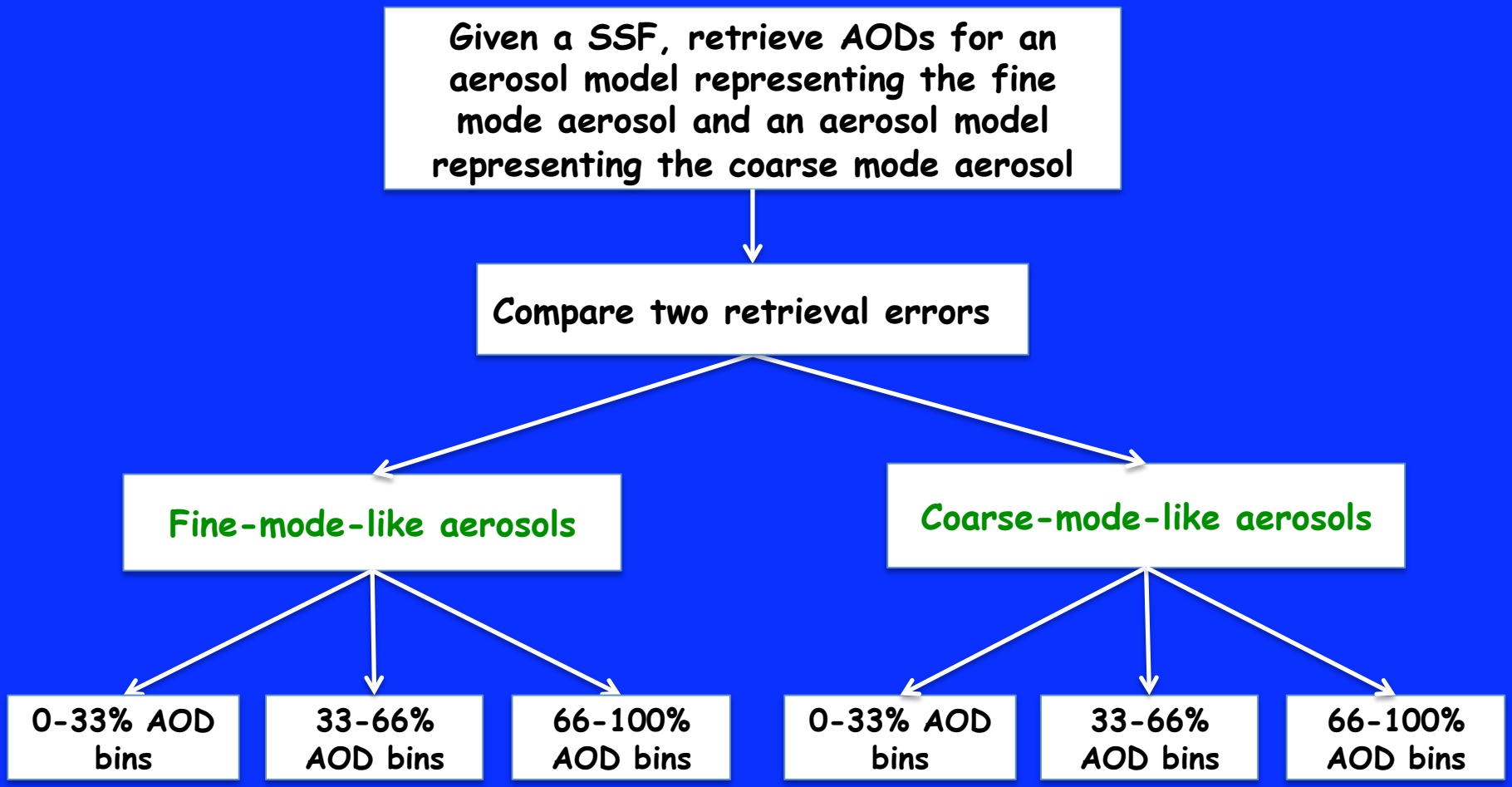
1: AOD-classified ADM

2: AOD-and-type-classified ADM
(two-model-minimal-retrieval-error approach with MODIS bands 1 and 2)

3: AOD-and-type-classified ADM
(AOD-fine-mode-fraction approach with MODIS bands 1 and 2)

2: AOD-and-type classified ADM

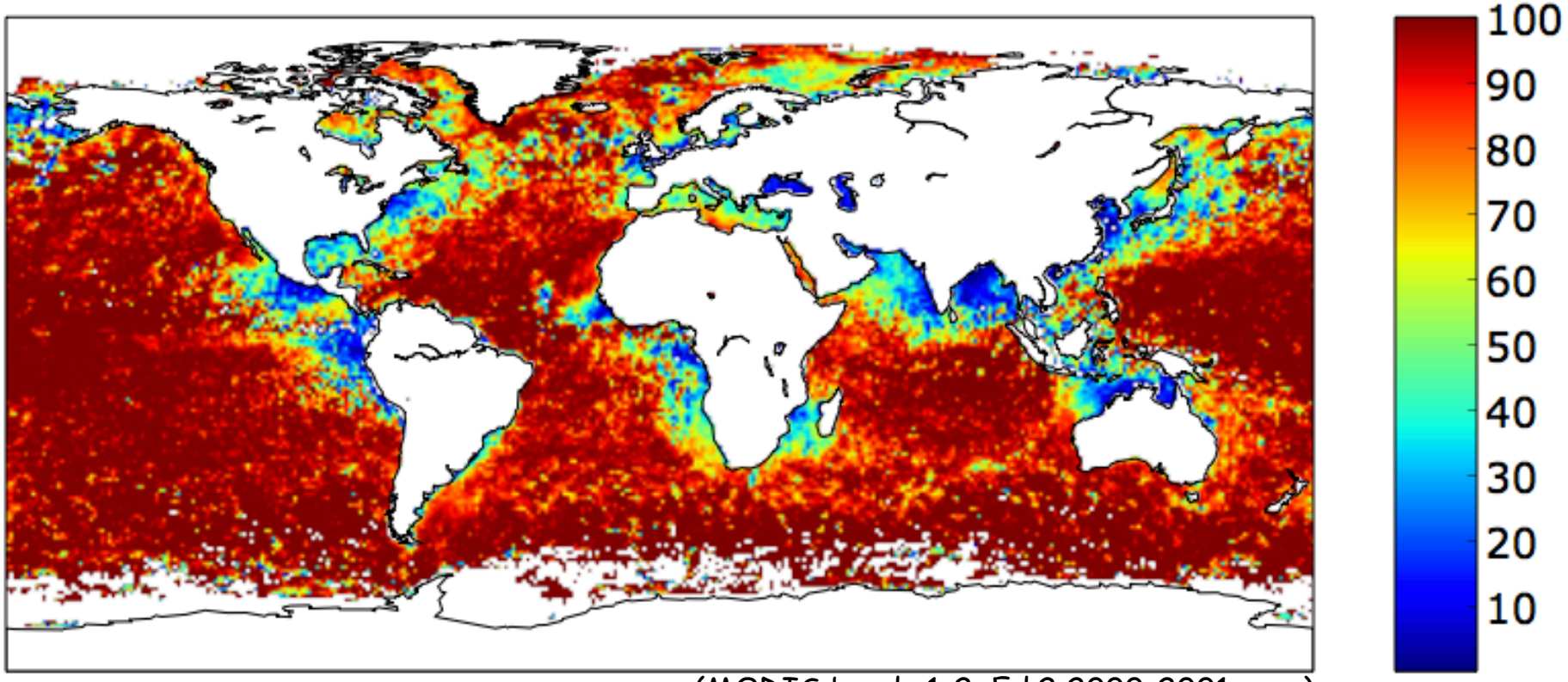
two-model-minimal-retrieval-error approach



Aerosol classification

percentage of coarse-mode-like aerosols

(OPAC dust-urban model)



(MODIS bands 1-2, Ed.2 2000-2001 raps)

Aerosol classification

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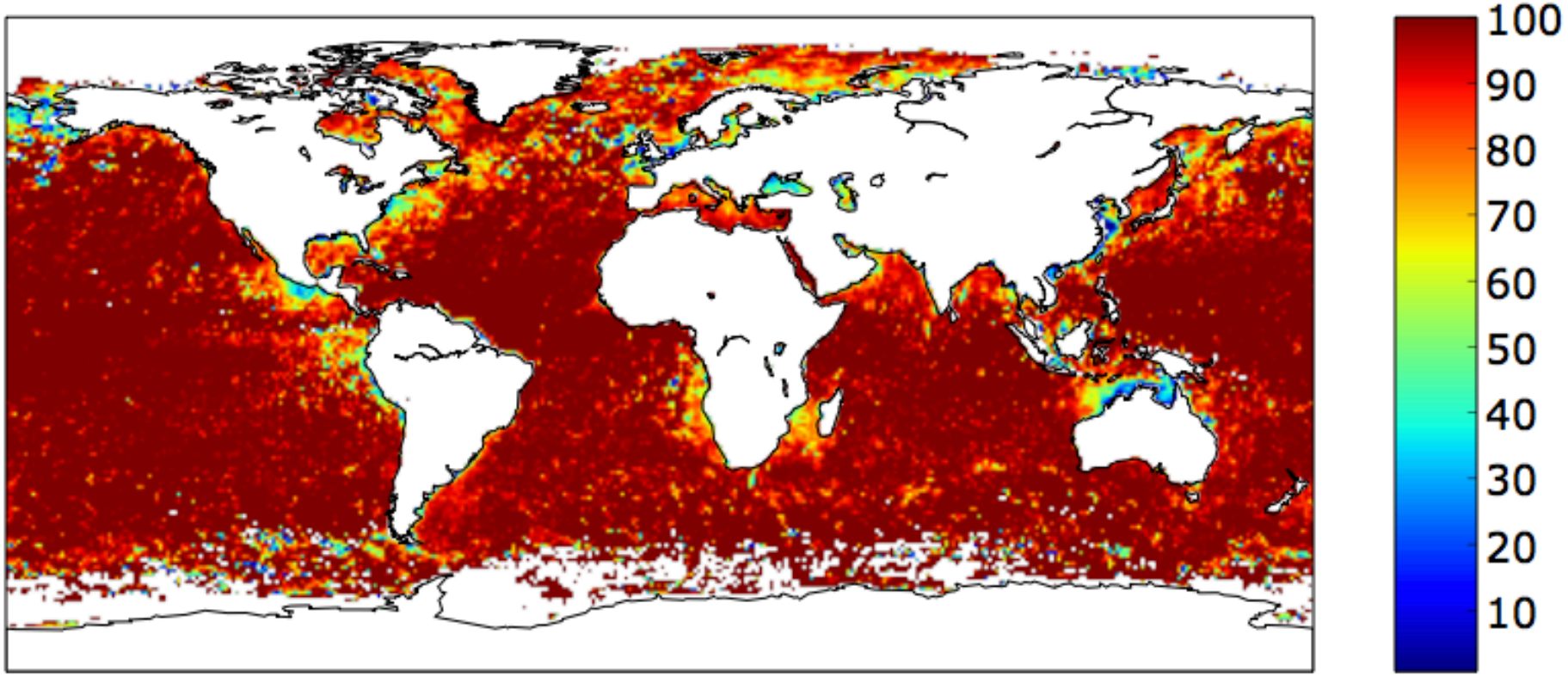
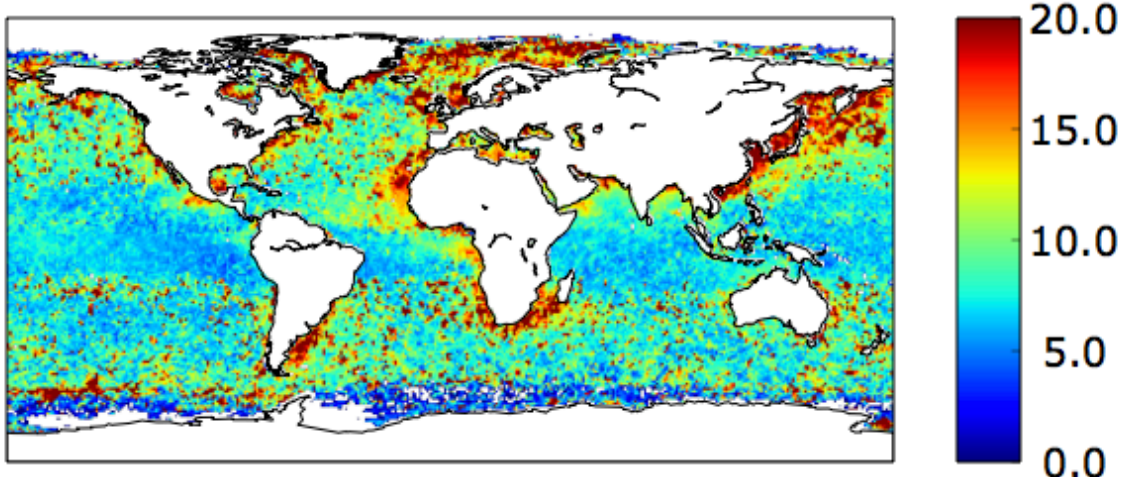


(MODIS bands 1-2, Ed.2 2000-2001 raps)

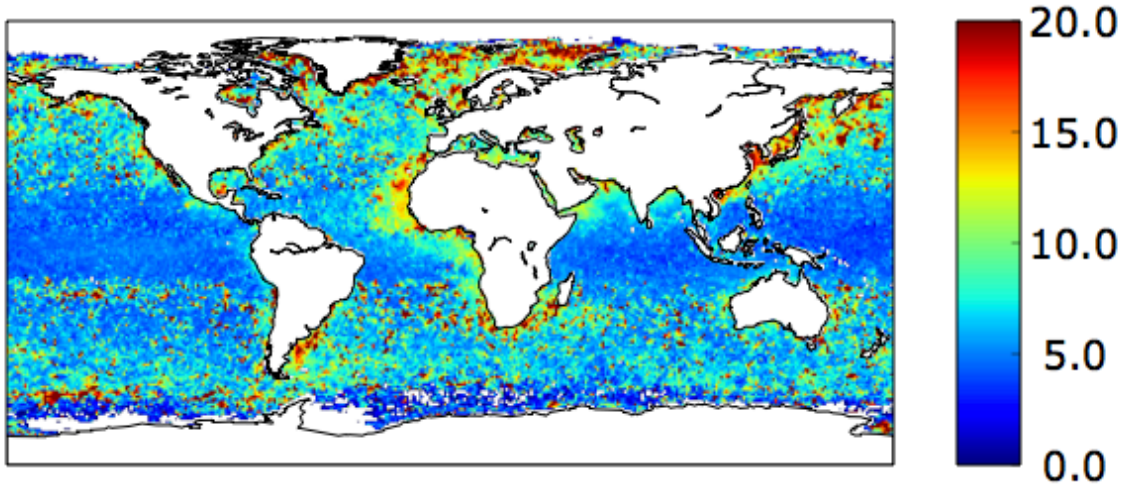
AOD-and-type-classified ADM

(OPAC dust-urban model, two-model-minimal- retrieval-error approach)

Ed.2 ADM RMS



New ADM RMS



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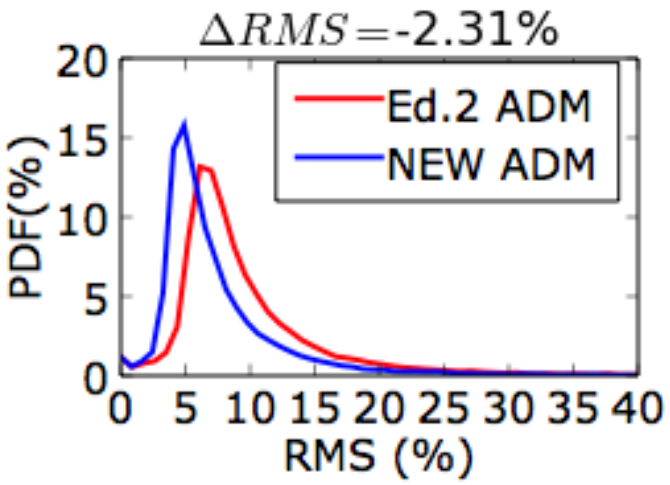

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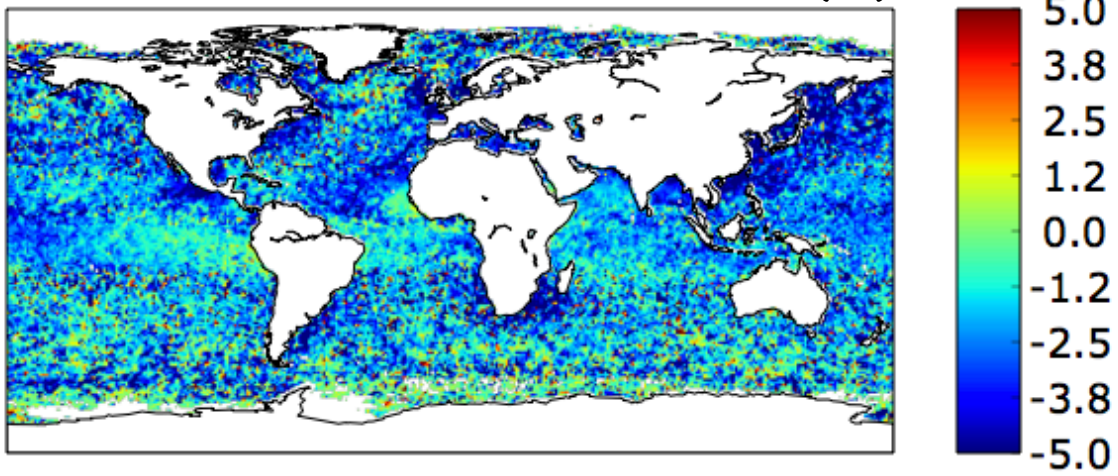
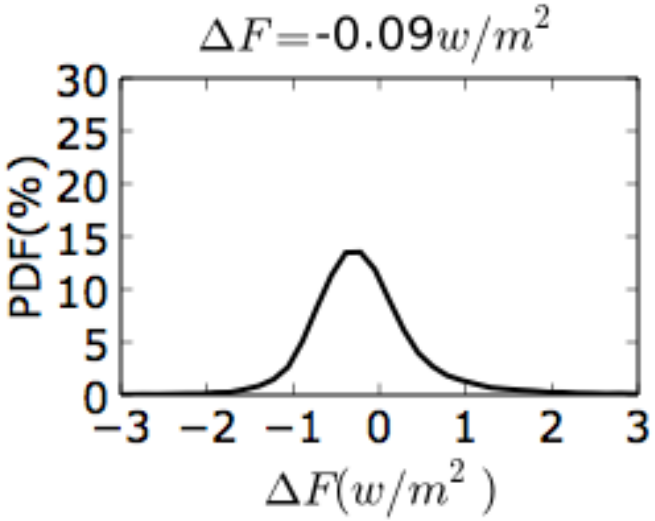
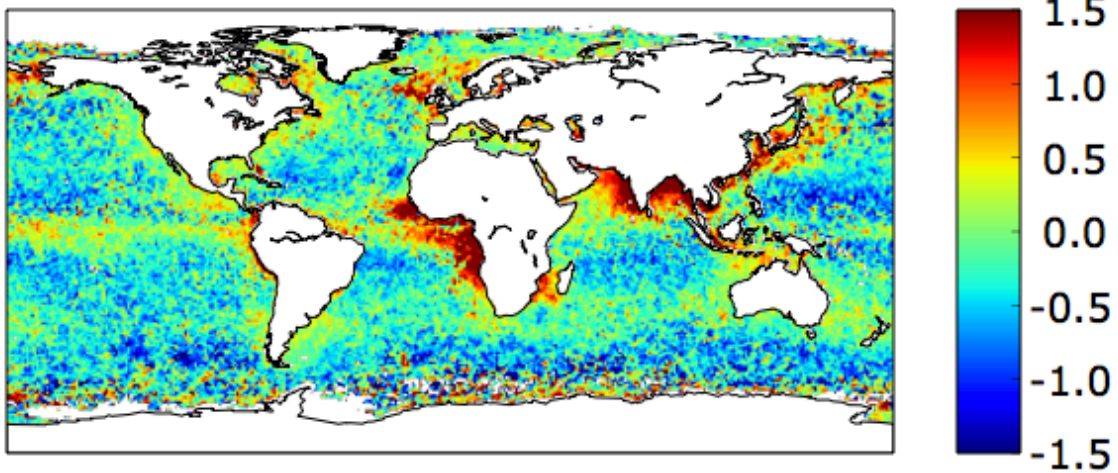




ΔF (w/m²)



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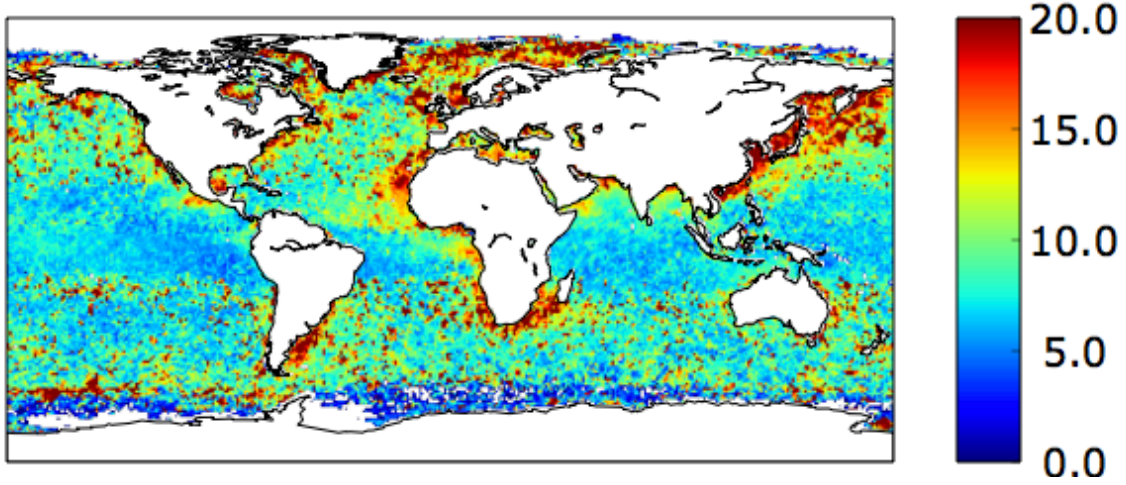

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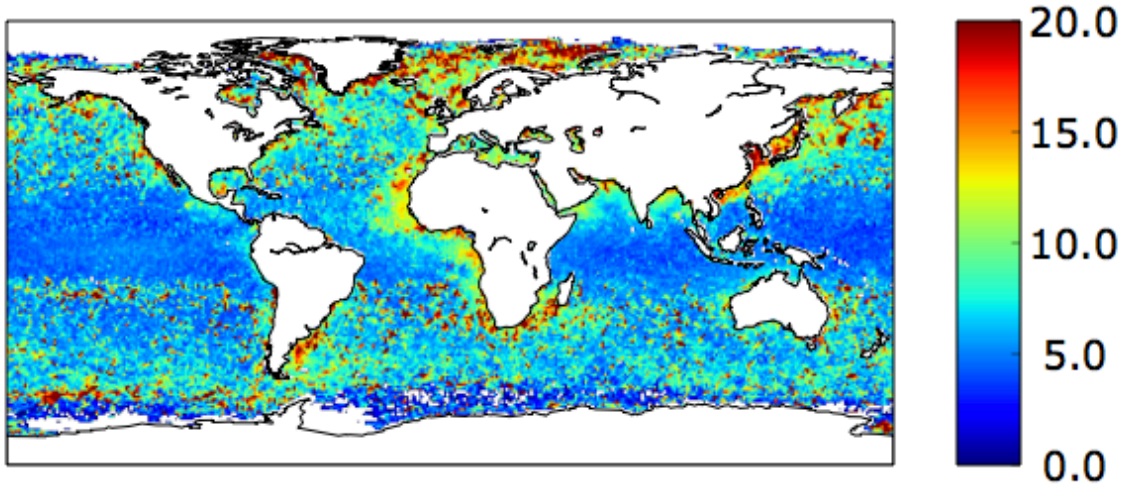

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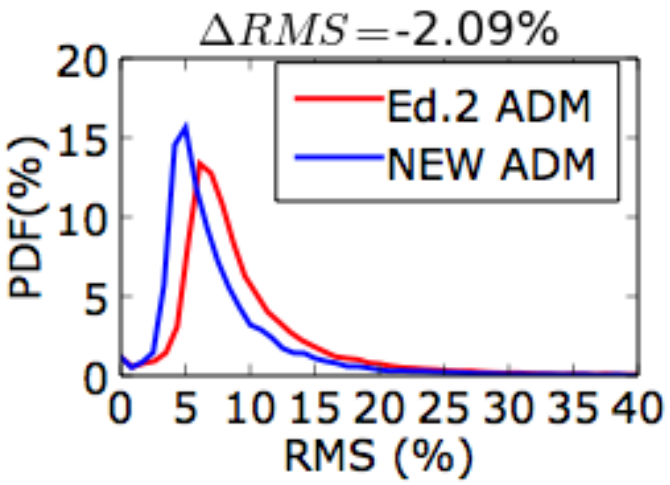

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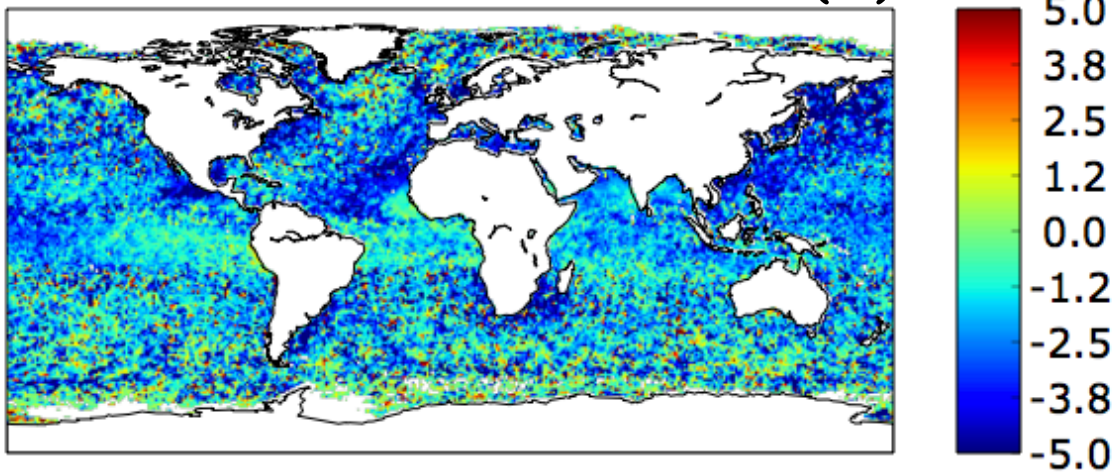

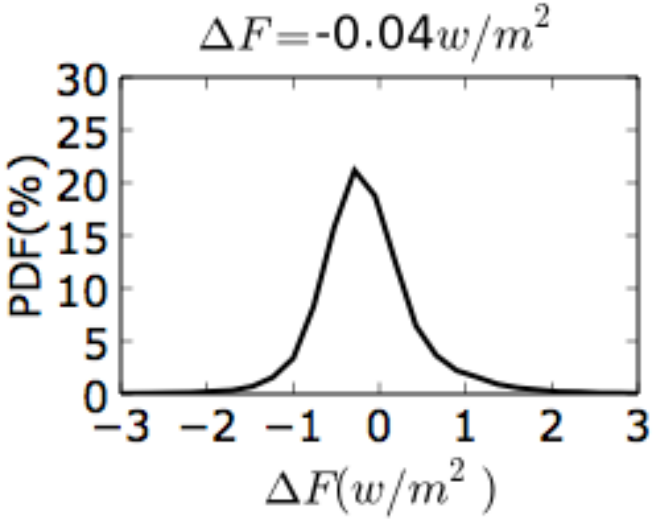

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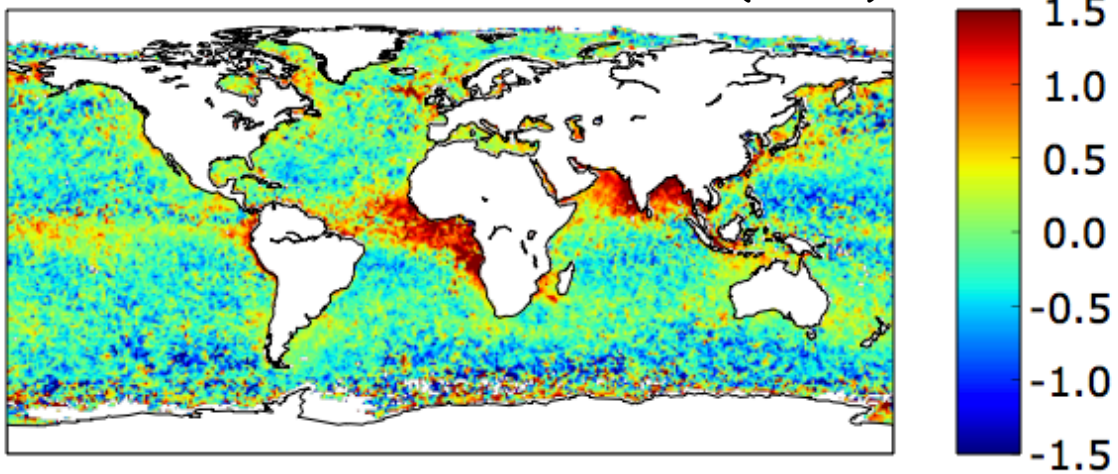

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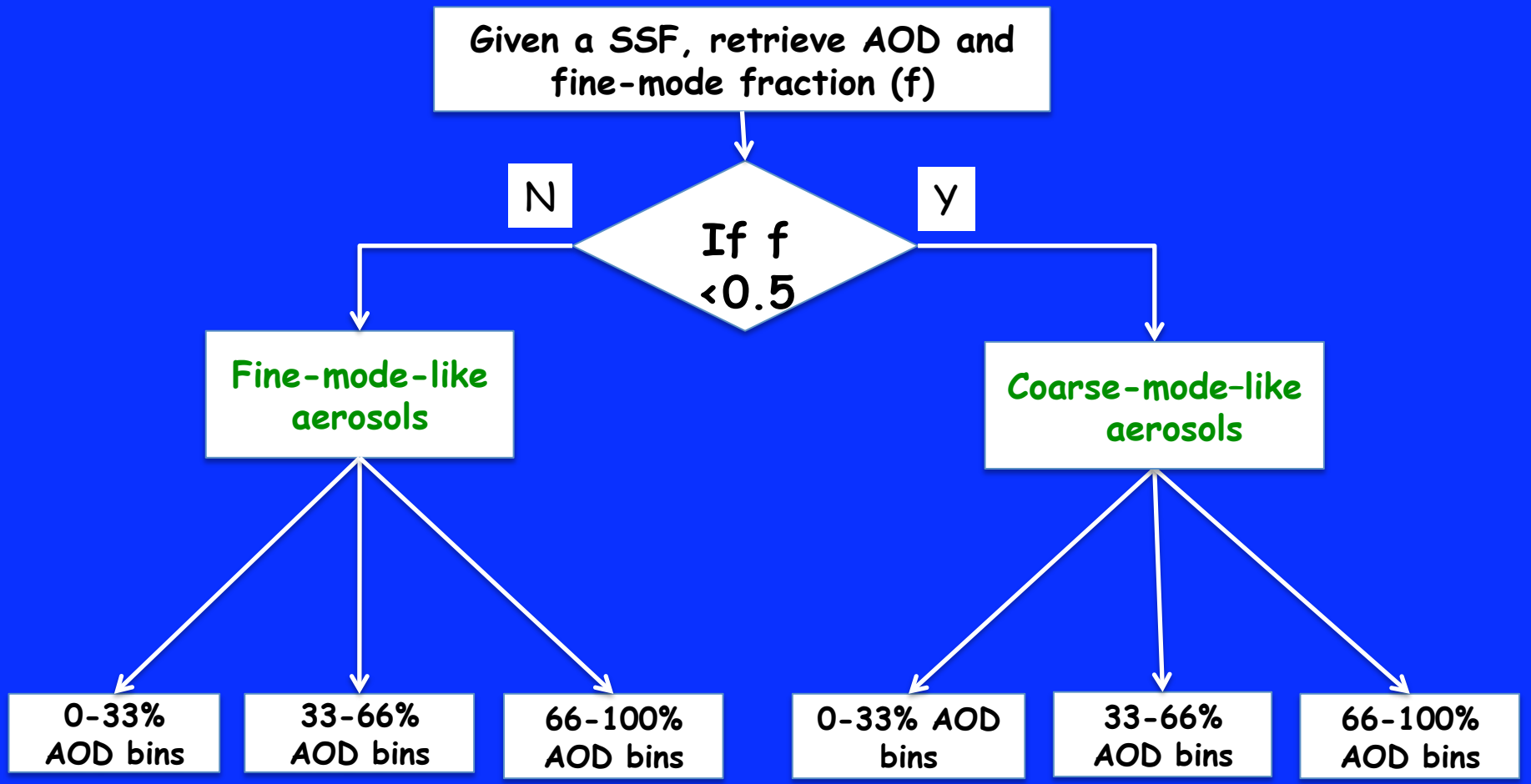
3: AOD-and-type-classified ADM

AOD-fine-mode-fraction approach

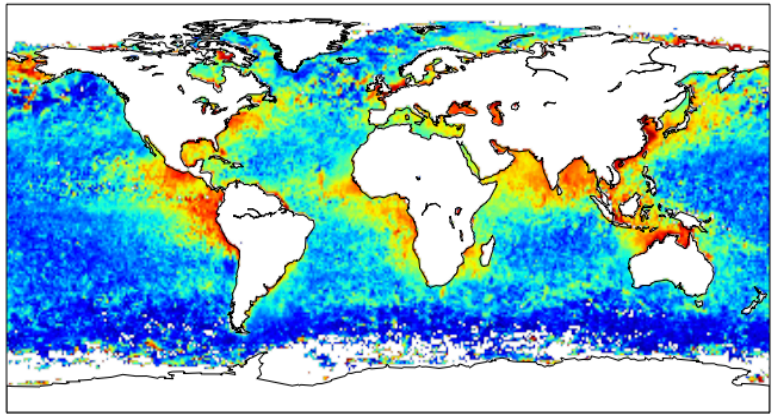


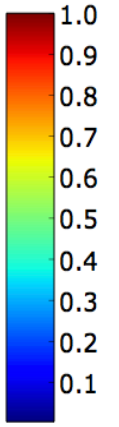
Aerosol and fine-mode fraction retrieval

CERES (OPAC dust-urban model)

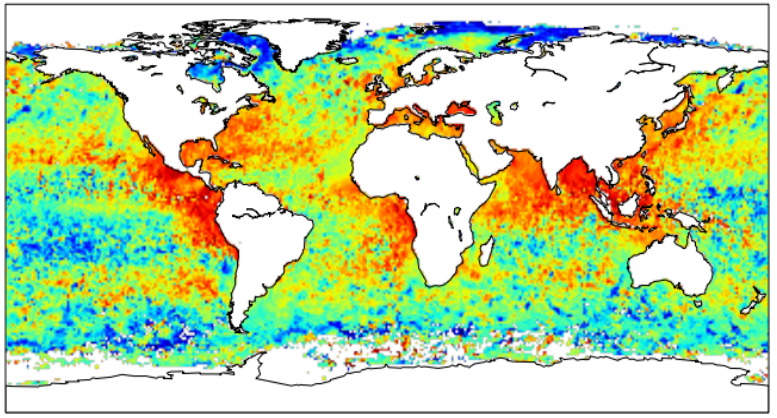
MODIS

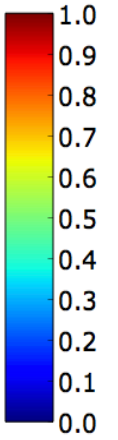
Fine mode fraction



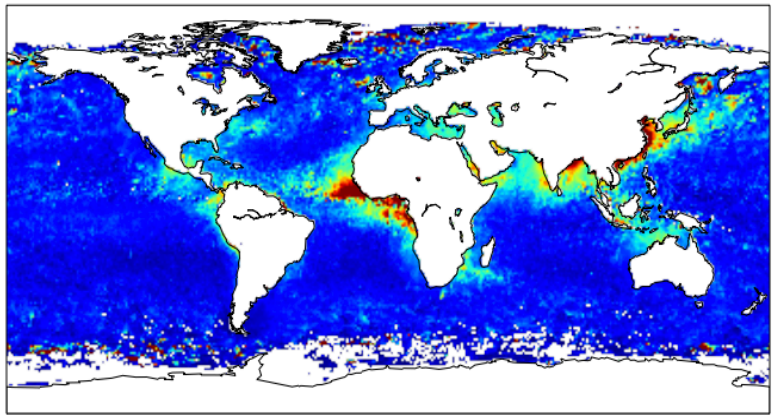


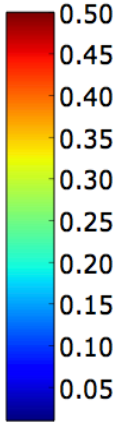
Fine mode fraction





AOD





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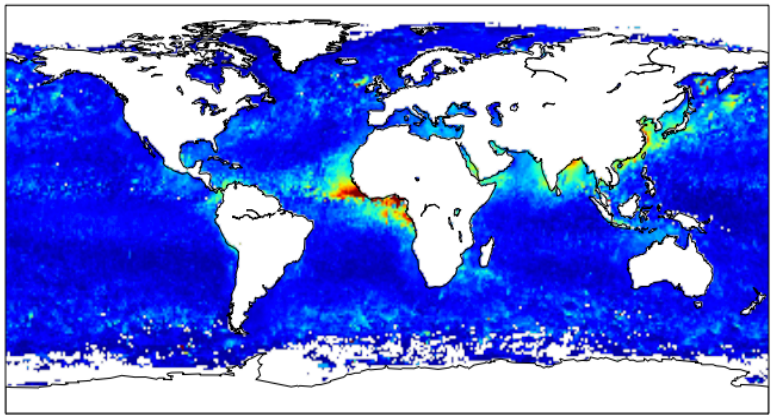
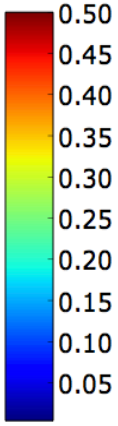




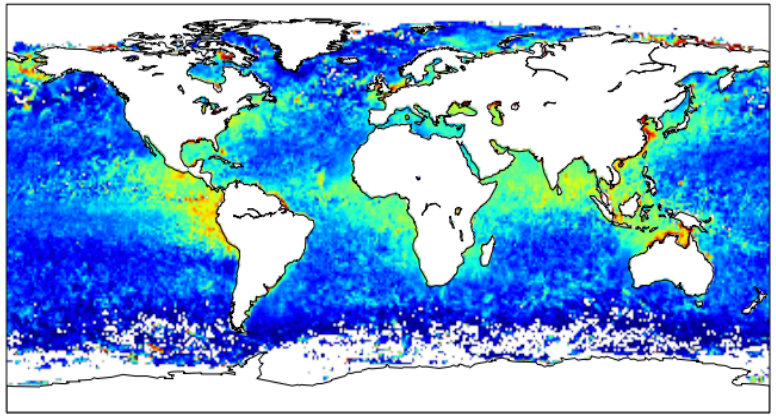
(MODIS bands 1-2, Ed.2 2000-2001 raps)

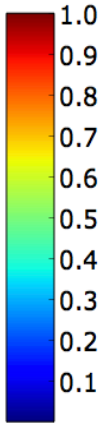
Aerosol and fine-mode fraction retrieval

CERES (MODIS 1st-9th model)

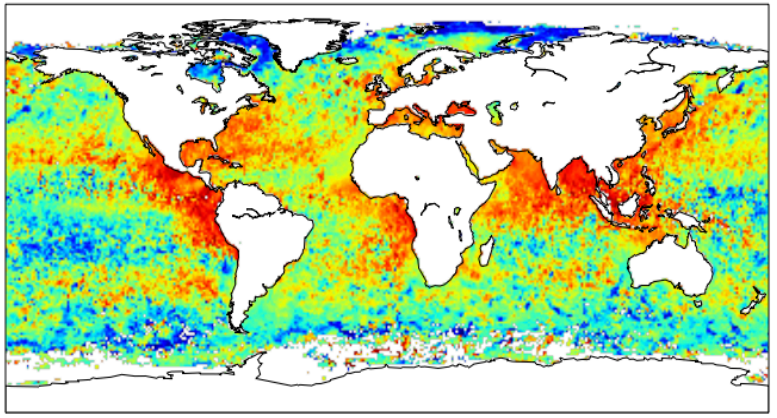
MODIS

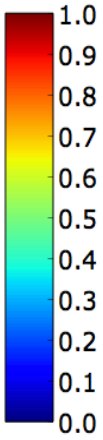
Fine mode fraction



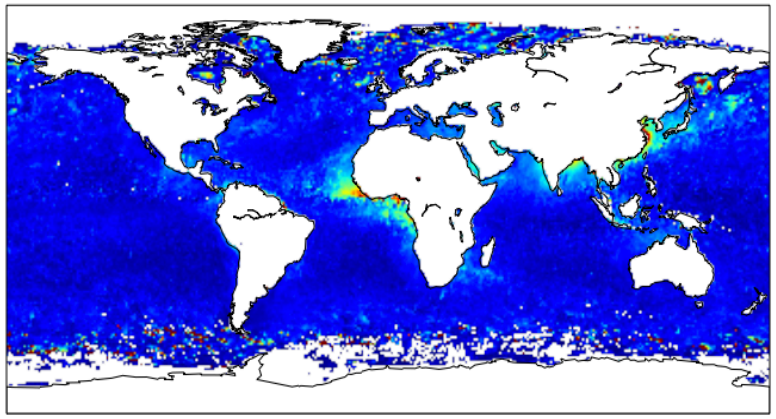


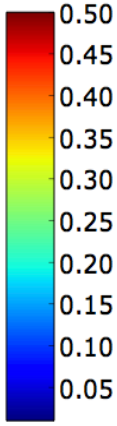
Fine mode fraction



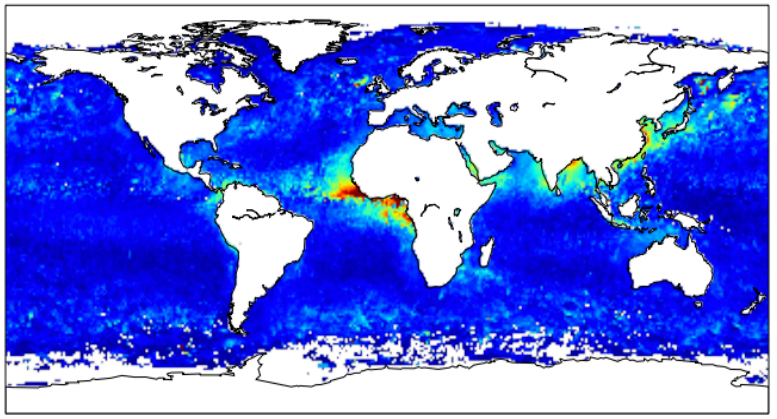


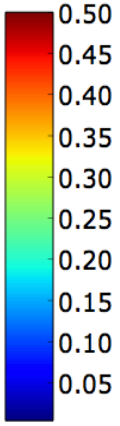
AOD





AOD



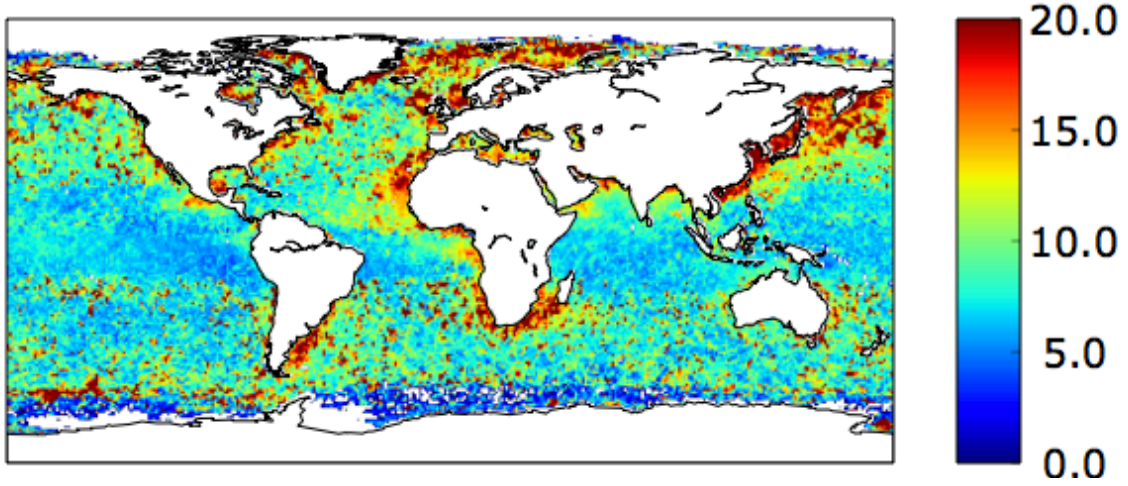


(MODIS bands 1-2, Ed.2 2000-2001 raps)

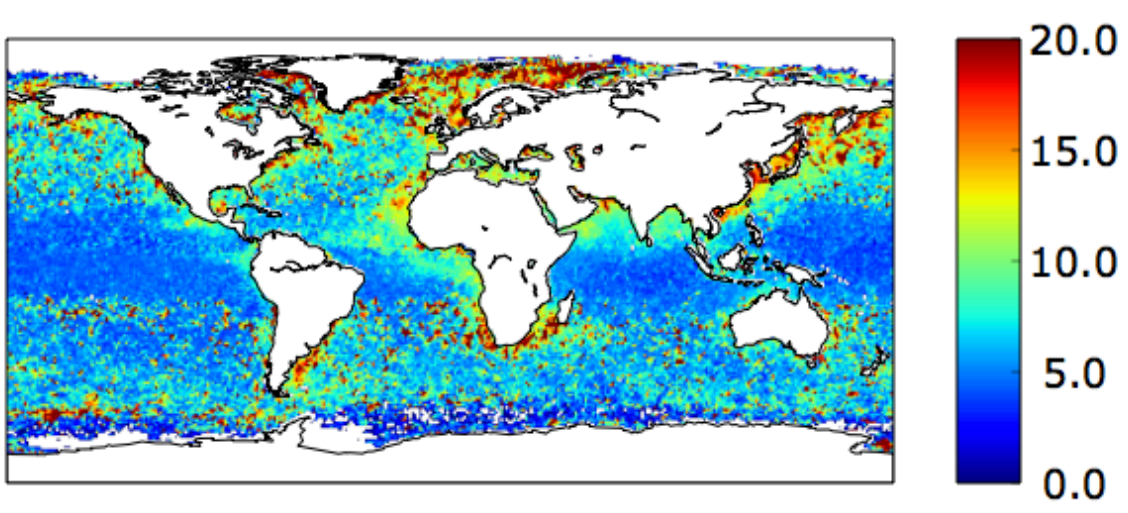
AOD-and-type classified ADM

(OPAC dust-urban model, AOD-and-fine-mode-fraction approach)

Ed.2 ADM RMS



New ADM RMS



AOD-and-type classified ADM

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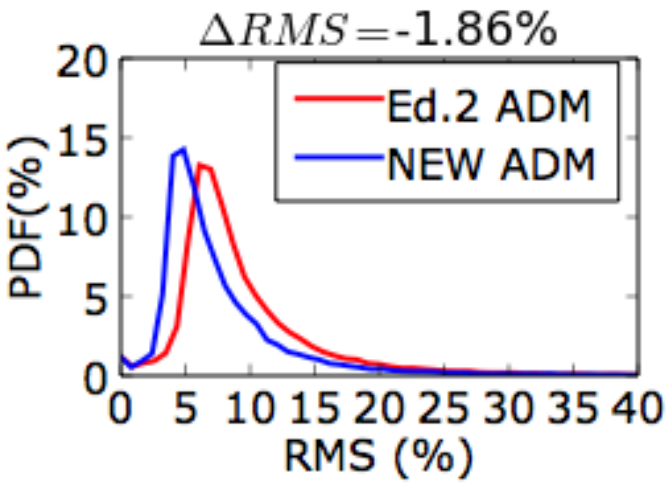
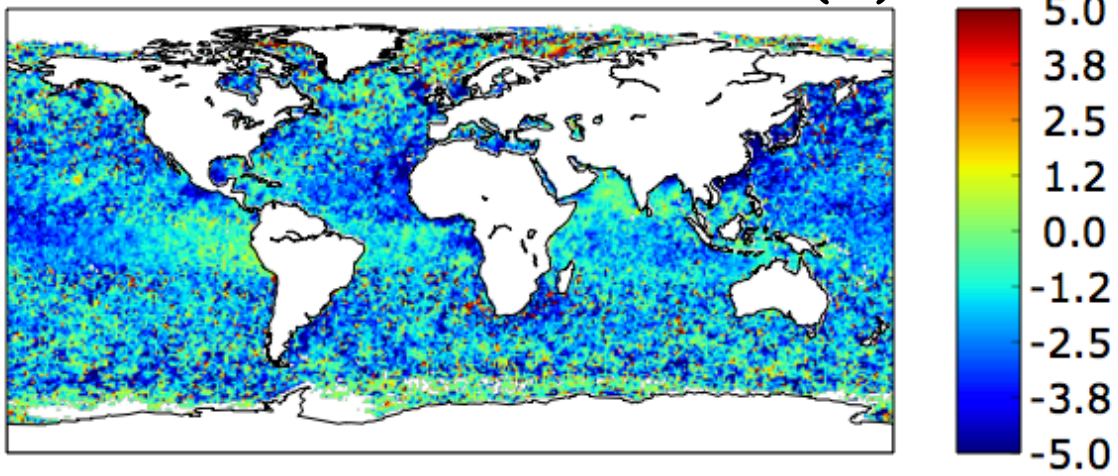
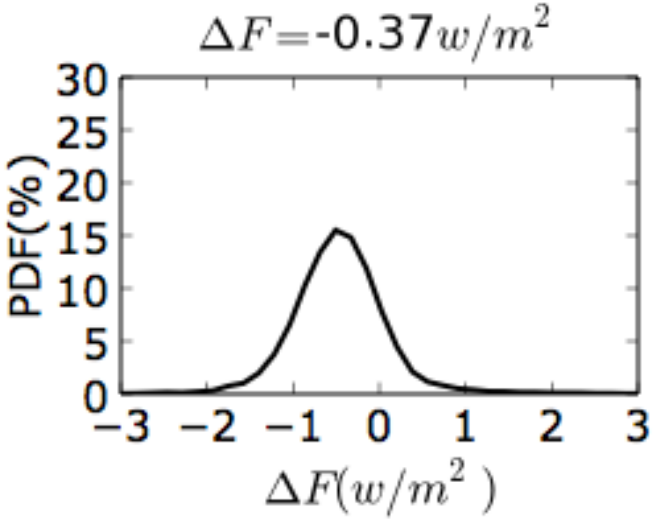
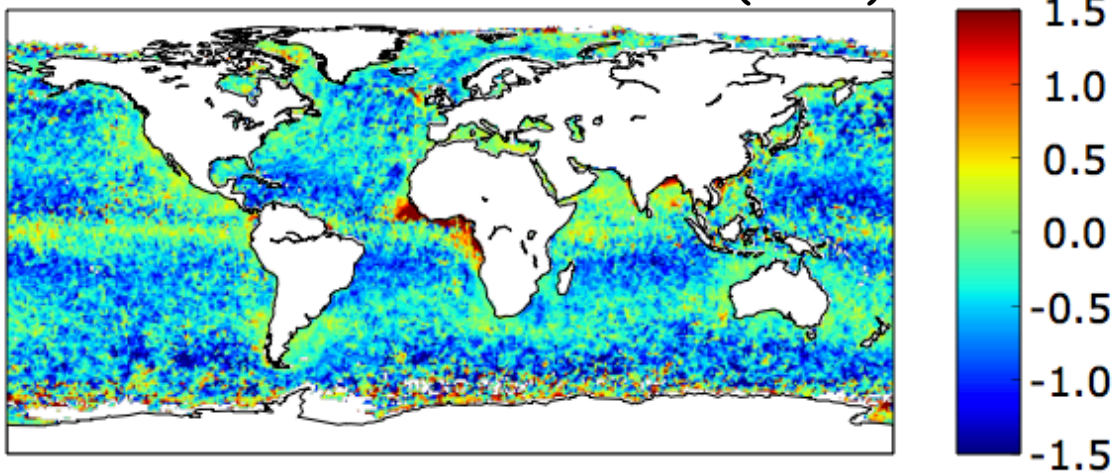


New – Ed. 2 ΔRMS (%)





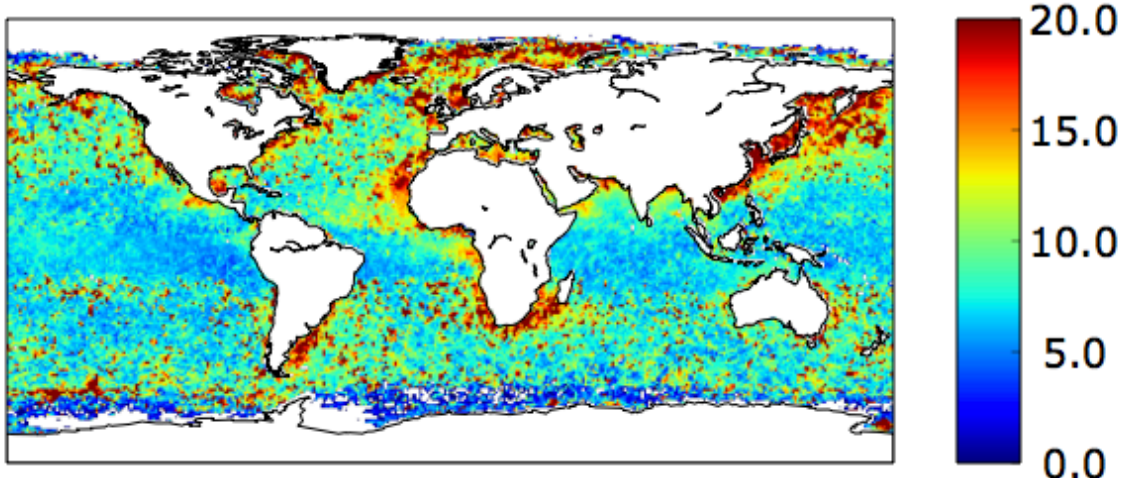
ΔF (w/m²)



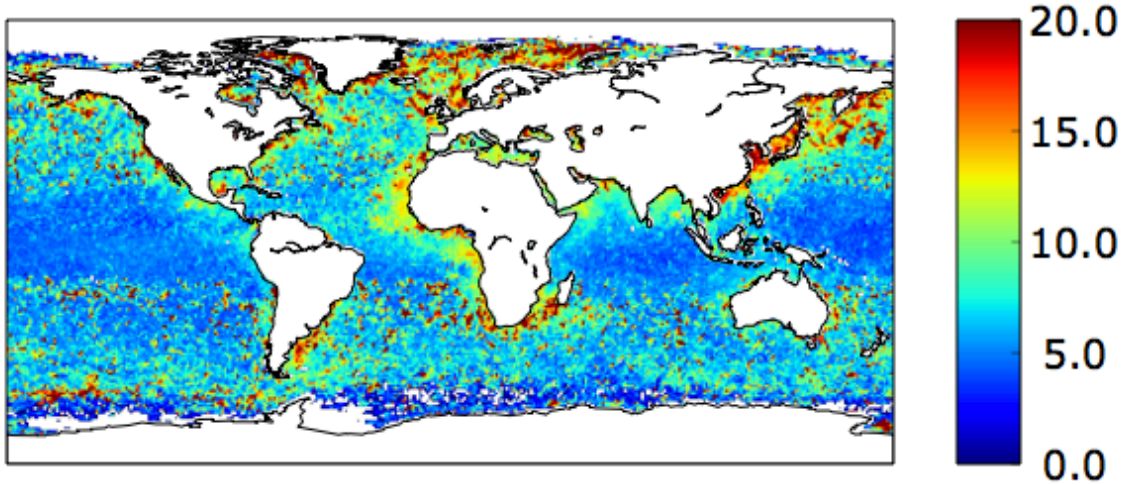
AOD-and-type classified ADM

(MODIS 1st-9th model, AOD-and-fine-mode-fraction approach)

Ed.2 ADM RMS

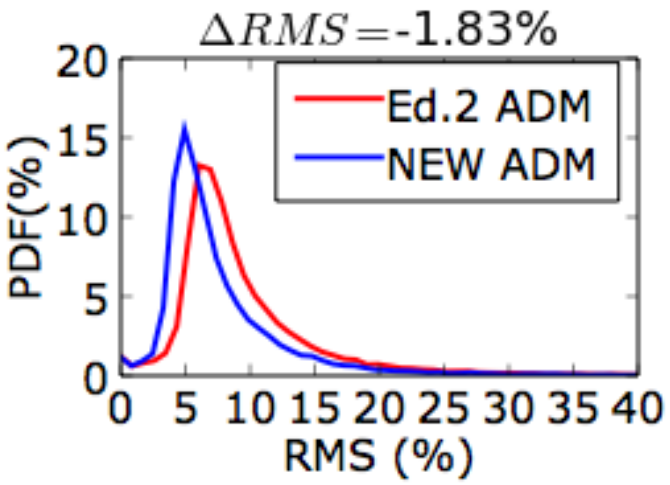


New ADM RMS

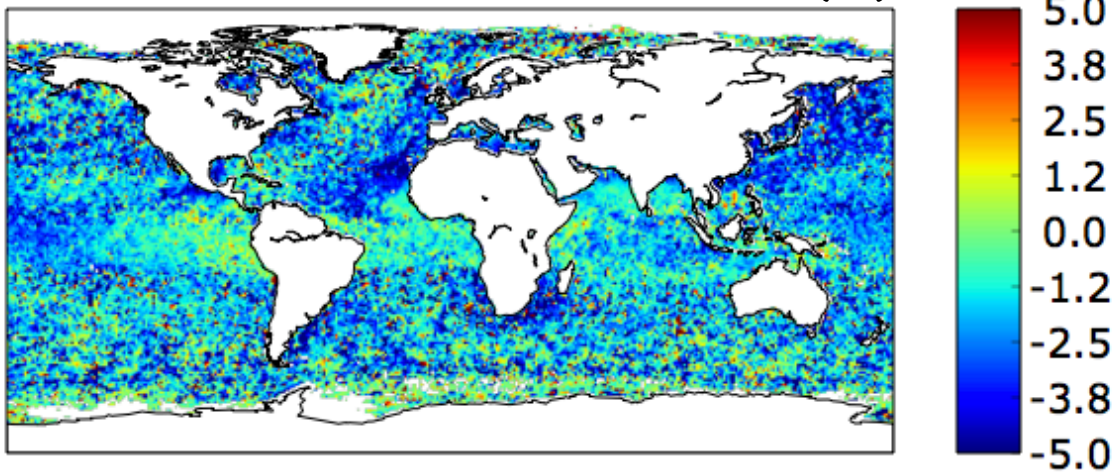


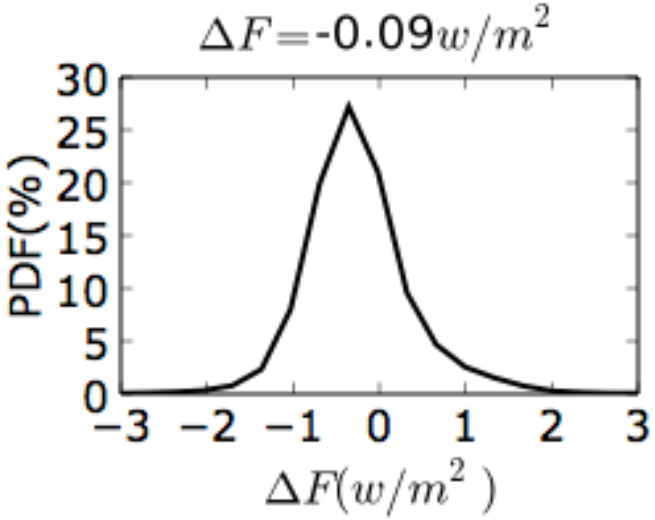
AOD-and-type classified ADM

(MODIS 1st-9th model, AOD-and-fine-mode-fraction approach)

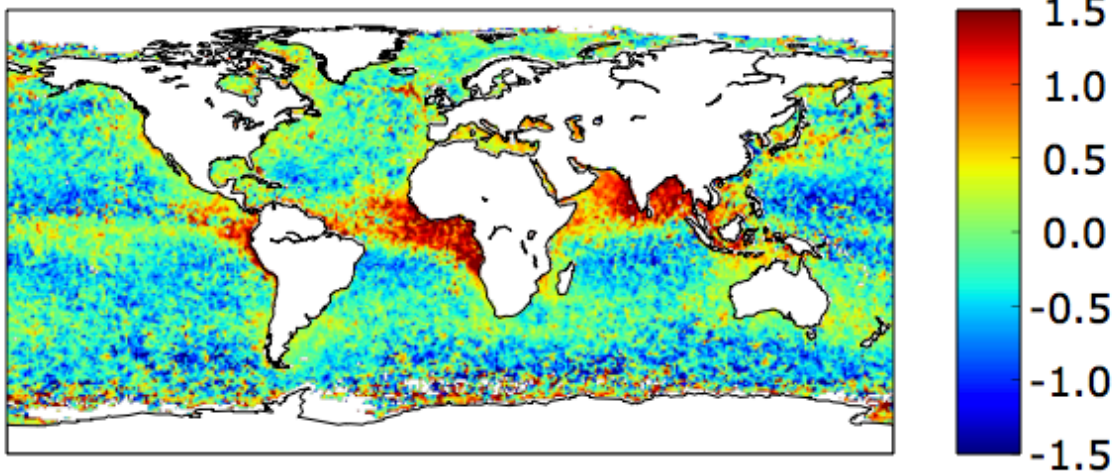


New – Ed. 2 ΔRMS (%)





ΔF (w/m²)



Summary

ADM		Ed.2 ADM RMS (%)	ΔRMS (%)	ΔF(w/m^2)
AOD-classified	Three AOD-percentile bins	10.55	-2.00	0.03
AOD-and-type-classified (two-model-minimal-retrieval-error approach)	OPAC dust-urban model	10.55	-2.31	-0.09
	MODIS 1st-9th model	10.55	-2.09	-0.04
AOD-and-type-classified (AOD-and-fine-mode-fraction approach)	OPAC dust-urban model	10.55	-1.86	-0.37
	MODIS 1st-9th model	10.55	-1.83	-0.09

- The performance of AOD-classification ADM is nearly as good as the AOD-and-type-classified ADMs;
- As the performance of AOD-and-type-classified ADM, OPAC dust-urban model combination is better than MODIS 1st-9th model combination.

Future work

- The ADM performance with AOD-and-fine-mode-fraction approach could be better with a different fine-mode-fraction stratification.
- The ADM performance can be potentially improved with different MODIS aerosol model combinations.
- Examine ADM performances with Ed.4 cloud product and MODIS band 1-6 radiances.